FoleyAutomatic

Physically-based Sound Effects for Interactive Simulation and Animation

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SIGGRAPH 2001
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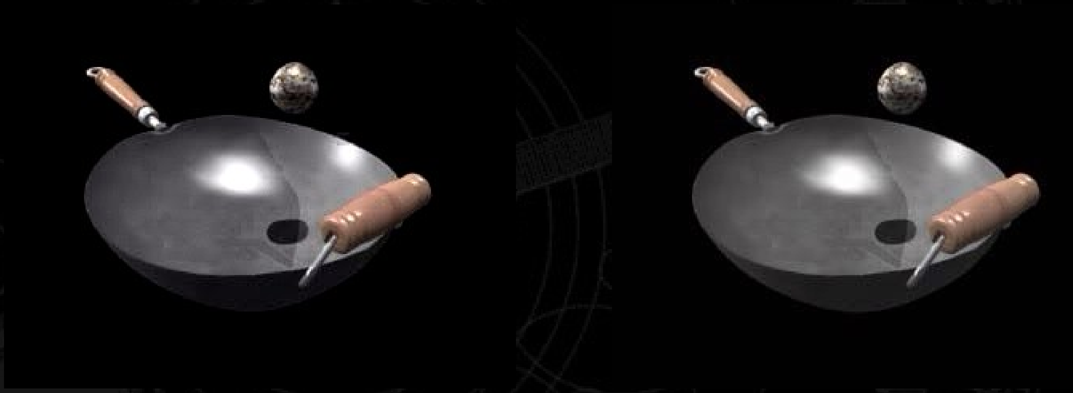
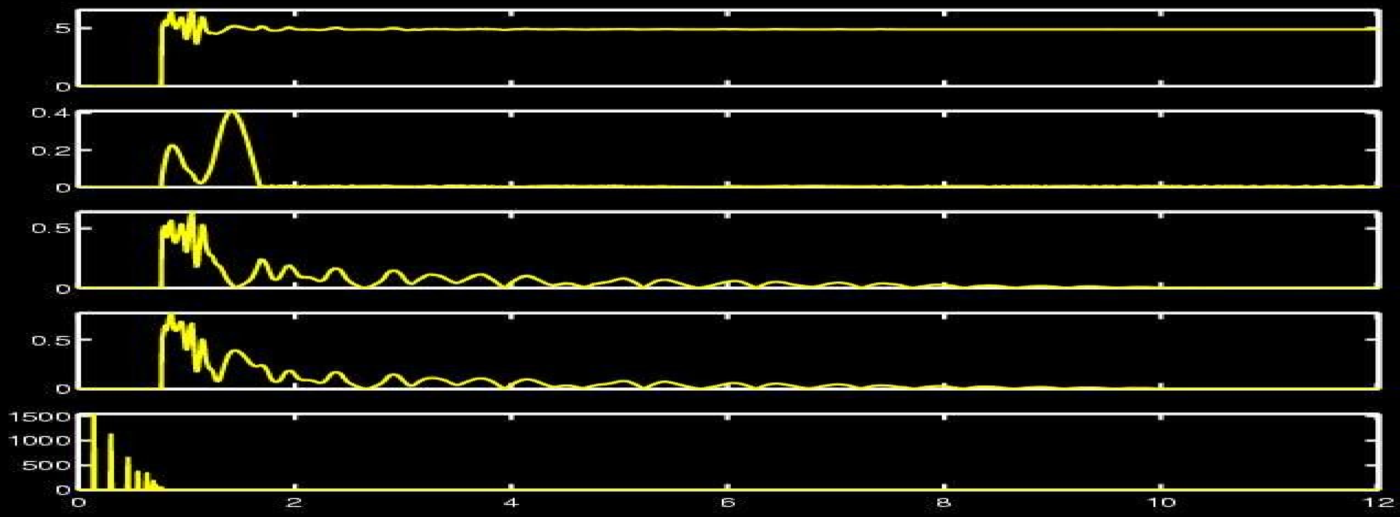
Non-speech & Non-music = Foley

Contact sounds important:

- Provide auditory feedback
- Accompany touch
- Give information about material
- Enhance immersive feeling
- Often operate on subconscious level

Simulation Based Sound-effects





Audio parameters

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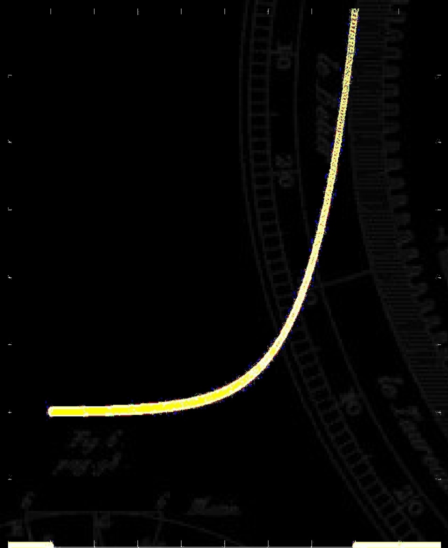
Hand-crafted Sound-effects

Draw excitation and apply to sword



Speed/force profile

Sword 1

Sword 2

Damped

Ribbed

Stick

Bell

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FoleyAutomatic Features

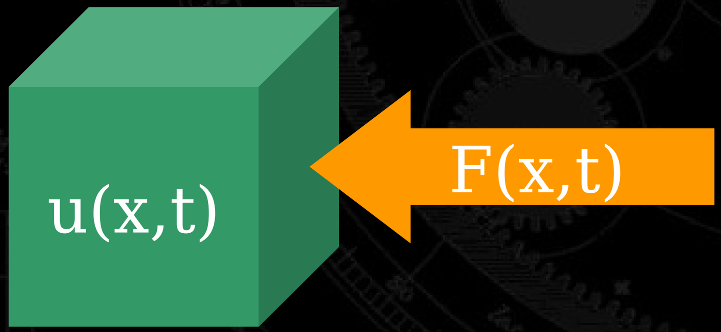
- Modal resonance models of solids [Cook 96, van den Doel & Pai 96]
- Location dependent sounds [van den Doel & Pai 98]
- Impact, slide, roll excitation models
- Real-time, low latency
- Model parameters measurable
- Easy integration with simulation/animation
- Practical (easy to deploy/author models)

Synthesis Method

Sound Samples

Propagation → Listener → Speakers

Surface *u(x,t)* of body responds to external contact force *F(x,t)*



$$\left[g\left(\frac{\partial}{\partial x^i}, x^i\right) - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right]u(x^i,t) = F(x^i,t)$$

[O'Brien, Cook, Essl SIG01]

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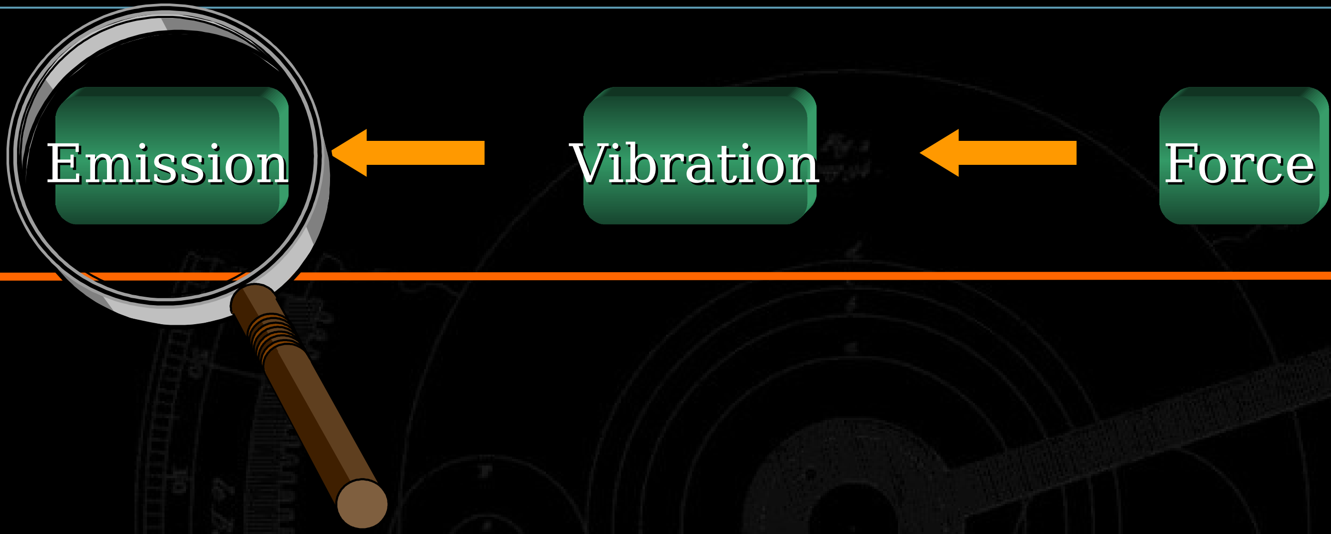


Sound pressure *s(t)* linear functional *L* of surface vibration *u(x,t)*

Emission ← Vibration ← Force

Impulse response,
modal model

Parameters measured [Pai et al, SIG01]

Emission ← Vibration ← Force

Impact

Sliding

Rolling

Wavetable

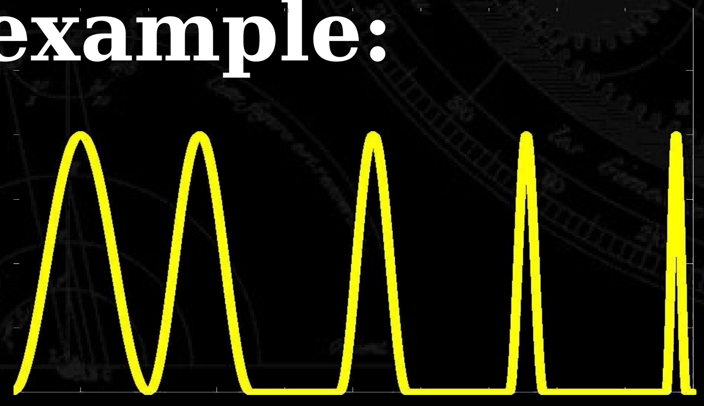
Stochastic

Impact Models

Impulsive forces

- I rdness
- M energy transfer
- M ro-collisions

For example:



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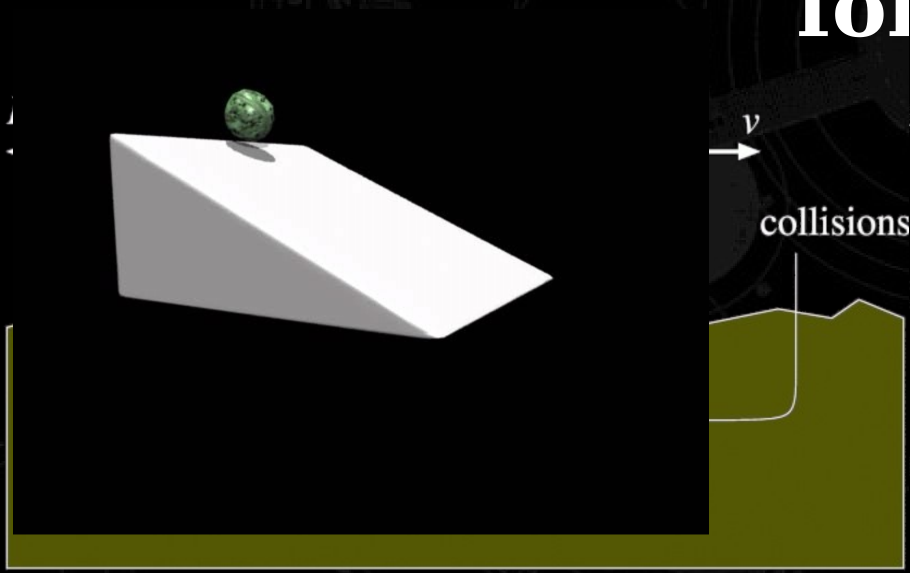
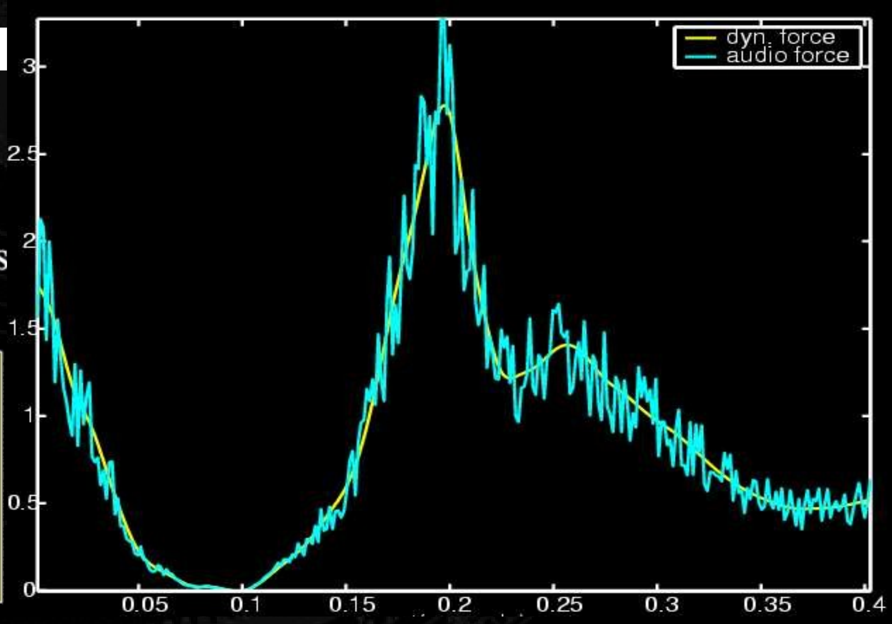
Sliding/scraping force models

Micro-collisions lead to noisy audio-fo





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Sliding/scraping force models

Wavetable approach:

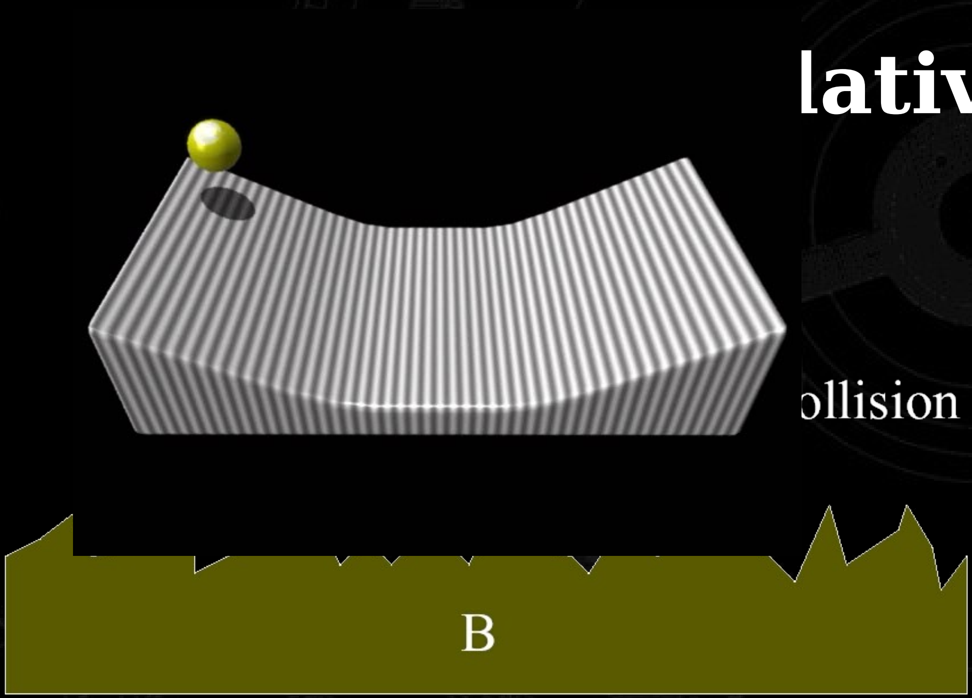
- Store force profile table
- Modulate amplitude with energy transfer
- Modulate rate with contact speed

Synthesis approach:

- Fractal noise represents roughness
- Filter through reson filter
- Resonance ~ contact speed
- Width ~ randomness of surface

Rolling force models

lative surface motion



Differences with sliding:

- Smoother: Use low pass
- More damping
- Harder to create
- Less understood
- Essential coupling?
- [Hermes 98, Stoelinga 01]

Implementation: Audio Synthesis

Audio synthesis

- Java Audio Synthesis System (JASS)
  - [van den Doel & Pai 01]
  - www.cs.ubc.ca/~kvdoel/jass (try it at home)
- 0.1% CPU per mode on Ghz Pentium III
- Real-time or offline
- Low latency

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Dynamic Simulation for Sound

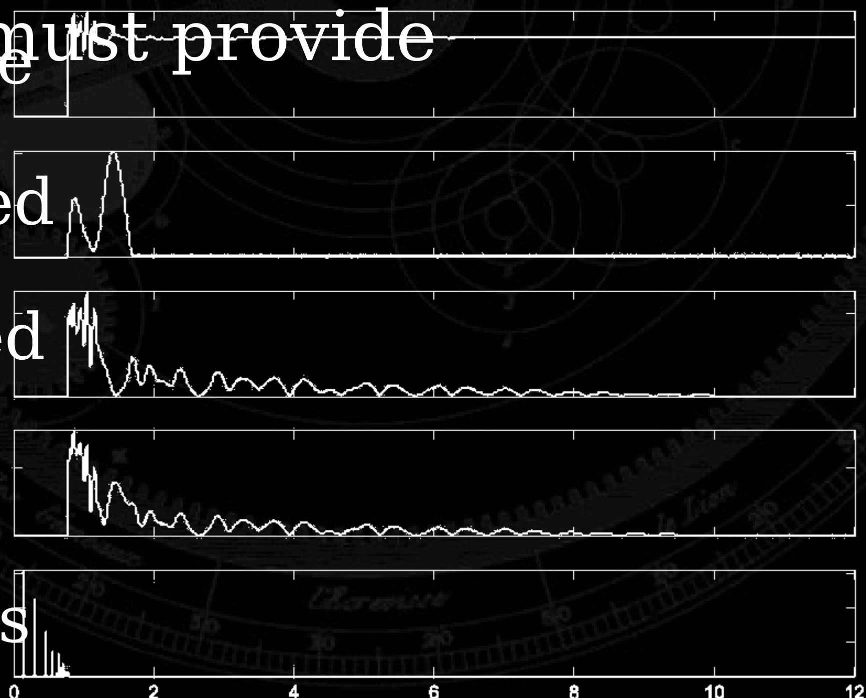
- Can be used with most multi-body techniques
- Simulation must provide

Contact force

Slipping speed

Rolling speed

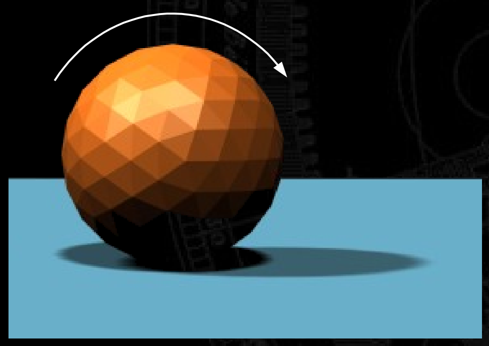
Impulses

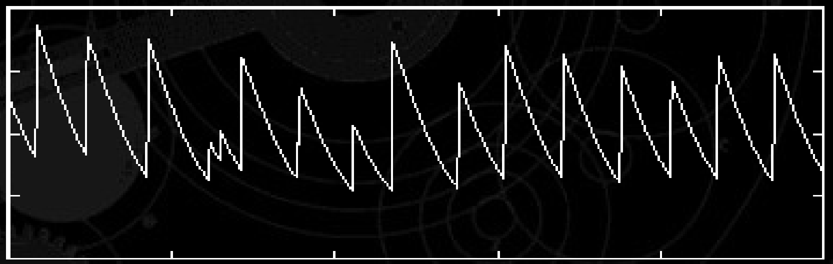


…and locations

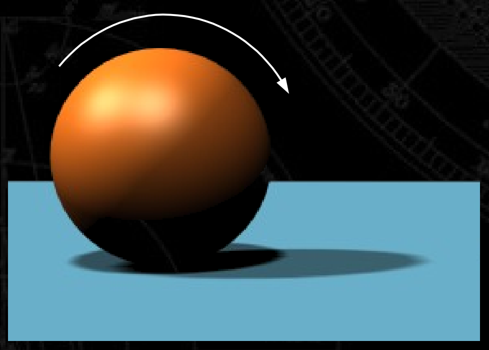
Smooth Surfaces

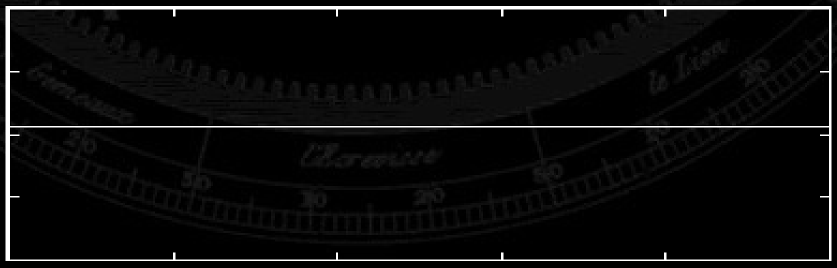
- Polyhedral objects do not lead to smooth rolling forces





- Instead use smooth surfaces directly





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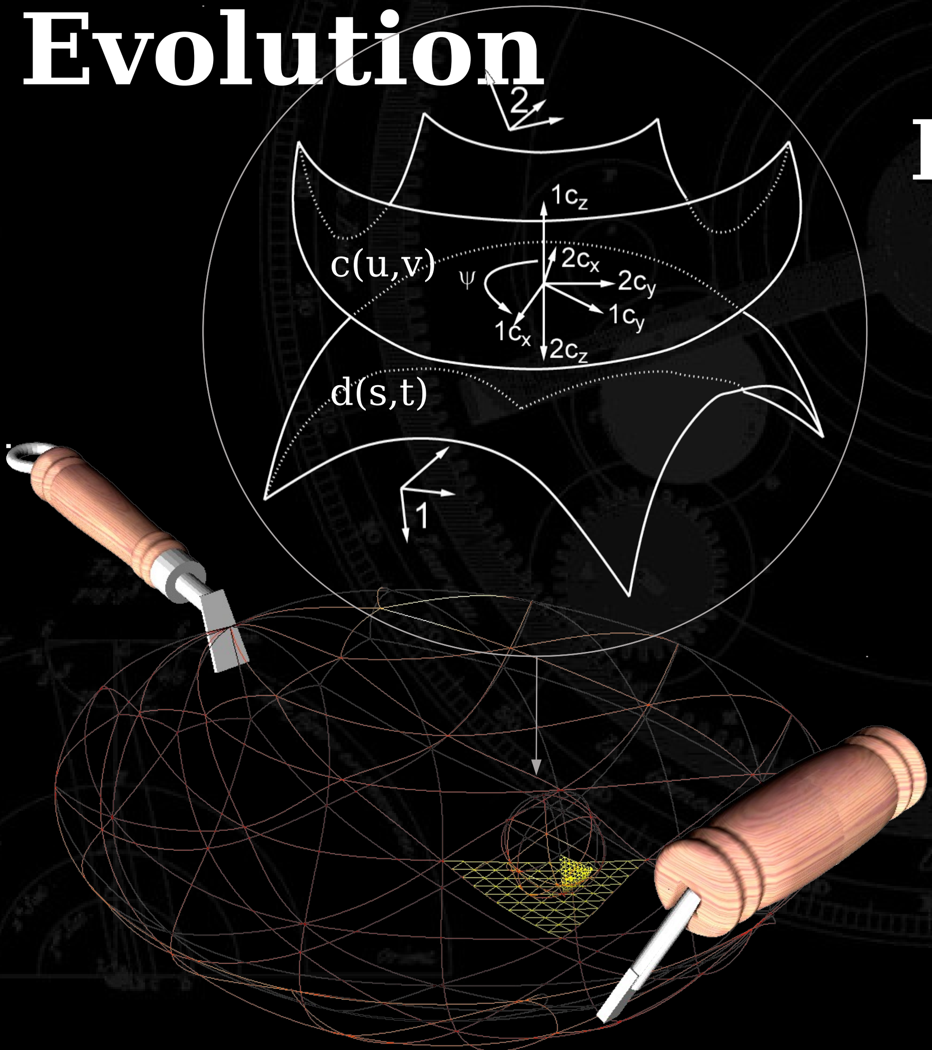
Contact Dynamics for Smooth Surfaces: Contact Evolution



Evolve the contact in Reduced coordinates

$$q = (u,v,s,t,\psi)$$

$$\ddot{q} \rightarrow \dot{q} \rightarrow q$$

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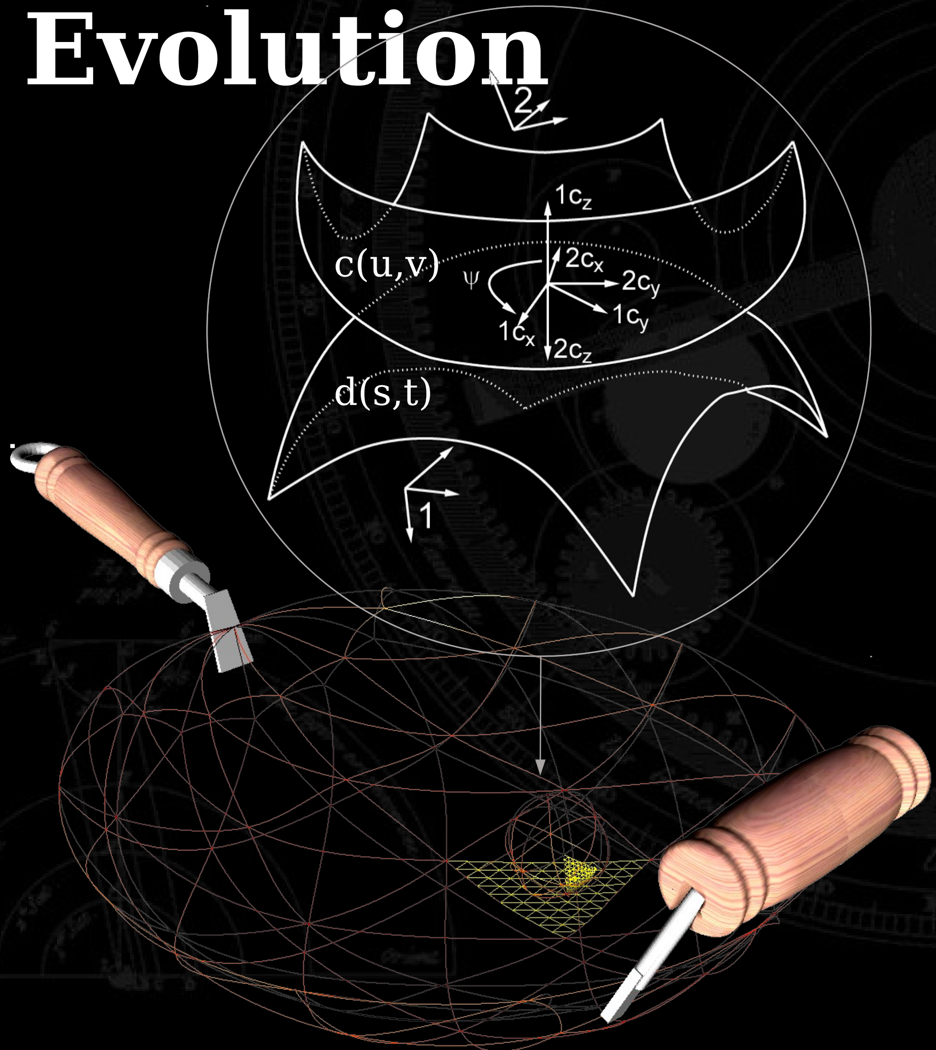

- Piecewise parametric surfaces, subdivision surfaces
- Explicit integration, no stabilization
- Multiple contacts and conforming contacts require different coordinates or other methods

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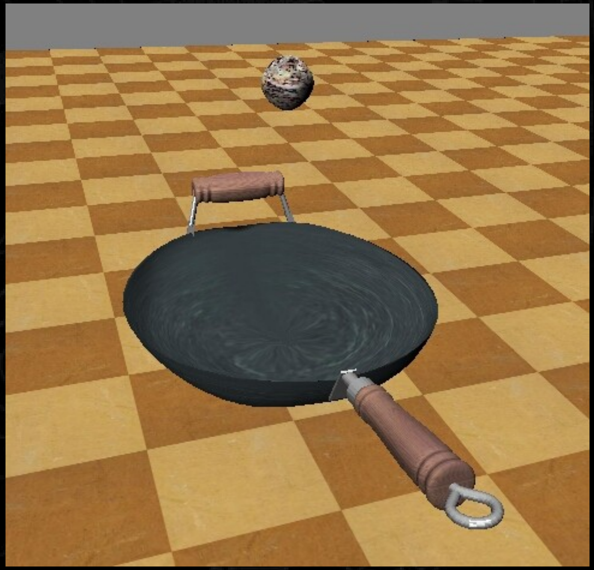
Demo

- Loop subdivision surfaces
- Sphere tree for collision detection
- Chatterjee Ruina collision response
- Interaction with PHANTOM
- Sound with JASS



Conclusions

FA is practical system for contact sounds

- Modal resonance models for objects
- Measured or stochastic excitation models
- Driven by simulation parameters
- High quality
- Efficient
- --- The End ---

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